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An Analysis of Selected Economic and Methodological Issues Relating to Time Series Research in Accounting

William S. Hopwood
James C. McKeown

College of Commerce and Business Administration
Bureau of Economic and Business Research
University of Illinois, Urbana-Champaign

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William S. Hopwood, Associate Professor
Department of Accountancy

James C. McKeown, Professor
Department of Accountancy

Abstract

This paper focuses on identification, synthesis and integration of what the authors consider to be some of the main economic and methodological issues that have emerged within the last several years, relating to time series research in accounting. This discussion considers different trends which might occur within this area of research in the short- and intermediate- term futures.

In recent years there has been a rapid growth of time series research in accounting. This has led to applications in several areas including those of auditing, financial reporting and management accounting. These studies have provided insight into the stochastic properties of key variables (e.g., sales, income and security price returns) within the accounting environment. Yet, at the same time, they have raised a large number of issues of both substantive and methodological nature. The purpose of this paper is to focus on some of what the authors consider to be the main issues relating to time series research in accounting. The primary focus is on the time series properties of accounting earnings since this has been the area of the largest quantity of research activity. The importance of this number is further evidenced by the Financial Accounting Board (FASB) which has stated, "The primary focus of financial reporting is information about earnings and its components" (FASB, 1978, p. ix).

In the next section we provide an overview of time series research in accounting (henceforth TSRA). The third section discusses economic issues, the fourth section discusses methodological issues and the final section considers future research.

OVERVIEW OF TSRA

The purpose of this section is to provide a brief survey of some of the major applications of time series research in accounting (For a detailed survey see Abdel-Khalik (1977-78), and Hopwood and Newbold (1981)). Subsequent sections build on the discussion presented here.

Factors Motivating TSRA

Since accounting is concerned with providing information for making decisions, it is not surprising that, as a discipline, it is concerned

with time series. This is because many types of decisions in the business environment involve the use of forecasts. For example, Norby (1973) found that a large percentage of financial analysts use earnings forecasts in their decision making process. In addition, Penman (1980) found that "insider" information relating to annual corporate earnings forecasts would enable an investor to earn 'abnormally' high returns (as measured by the capital asset pricing model of Sharpe (1964), Lintner (1965) and Mossin (1966)). Such a possibility has led the Securities and Exchange Commission to favor the concept of urging and/or requiring the disclosure of earnings forecasts. (For a detailed discussion see: Gonedes (1976), Penman (1980), Prakash and Rappaport (1974) and the Wall Street Journal (1978).) Their reasoning in part has been that, in the name of fairness, all potential investors should have equal access to the best forecast available, especially in the case where the forecast is based on inside information.

The use of forecasts by investors has been recognized in the accounting literature. For example, Beaver, et. al. (1968) considered "predictability" as a possible criterion for assessing the usefulness of alternative reported financial numbers. Under this view different numbers can be compared on the basis of how well they predict some variable of interest. For example, the Financial Accounting Standard Board (1976, p. 55) has stated:

> Earnings from an enterprise for a period measured by accrual accounting are generally considered to the most relevant indicator of relative success or failure of the earnings process of an enterprise in bringing in needed cash.

From this statement it can be seen that the "variable of interest" has been considered, at least by the Financial Accounting Standards Board, to be some form of cash measure. More debatable, however, is the notion of using past earnings to predict future earnings. While this type of approach has been operationalized (See, for example, Frank (1969) and Simmons and Gray (1969).), Revsine (1971) has convincingly argued that forcasted earnings is not a useful surrogate for cash flow.

Another motivating factor for TSRA has been information content/ capital market research. In testing the information content of accounting numbers, researchers have hypothesized that the capital market reacts to new or 'unexpected' information about a particular company. This has led to the computation of an expectation or prediction of the accounting number. The predicted number is then subtracted from the actual and the difference is then hypothesized to convey either 'good' or 'bad' news to the market. If this hypothesis is correct, then the sign (or magnitude) of the difference will be associated with abnormal returns as defined by the capital asset pricing model of Sharpe (1964), Lintner (1965) and Mossin (1966). This methodology was introduced by Ball and Brown (1968) and has been applied by many, including Foster (1977), Brown and Kennelly (1972) and Joy, et. al. (1977). The results of this body of research have consistently shown that earnings convey information to the market, thus supporting the hypothesis that accounting earnings information is, in fact, used by investors. For example, Foster (1977) used an autoregressive model on the seasonal difference of quarterly earnings to generate a prediction of earnings. The prediction

error from this forecast was found to be associated with abnormal returns as discussed above.

An additional application of TSRA is in the analytical review phase in auditing. As part of the audit, the accountant must conduct substantive tests to assess the reliability of account balances. In part, these tests include "analytical review of significant ratios and trends and resulting investigation of unusual fluctuations and questionable items" (Stringer (1975, p. 15)). This has motivated researchers (cf. Kinney (1978) and Albrecht and McKeown (1977)) to employ time series techniques for forecasting of account balances. Actual balances can be compared to forecasted balances and large differences can be considered for detailed investigation. This technique has the potential for being developed to the stage where it becomes of general use to auditors.

Another application of TSRA is analysis of security dividend-price returns. Fama (1965, 1970) showed that under certain conditions these returns should be white noise if prices reflect all publically available information. Therefore Praetz (1979) used spectral analysis to test for a flat spectrum. In addition, this white noise hypothesis was tested by Lookabill and McKeown (1976) by correlogram analysis. The results of these studies tend to be consistent with the hypothesis that prices do, in fact, reflect <u>all</u> publicly available information, thus indicating that an individual investor cannot gain any advantage over other market participants by use of publically available accounting data.

In summary, a number of factors have contributed to the motivation of TSRA. It should be pointed out that the above discussion is not meant to be comprehensive, and other undiscussed areas of application

exist. Foster (1977) discusses some of these including research relating to cost of capital, dividend policy and income smoothing. These issues are not discussed here since they have not received much attention relating to time series analysis in the accounting literature.

Research Findings

As discussed above, the primary focus of this paper is on the time series properties of accounting earnings, since this has been the area of the largest quantity of research activity, and since the FASB has stated that the primary focus of financial reporting is earnings and its components. Therefore due to these reasons and space considerations, the discussion that follows in the remainder of this paper will be limited to the time series analysis of earnings and its components.

Motivated by factors described above, and by simple scientific curiousity, researchers have devoted considerable effort in the last two decades toward gaining a better understanding of the time series properties of earnings. Central to this research has been an attempt to find a model or models that adequately describe the earnings process. Little attention in the accounting literature has been devoted to the time series properties of the components of earnings. This can at least partially be attributed to the fact only very recently has any consensus about the nature of the underlying earnings process itself begun to emerge. In addition, the study of earnings components, since it involves more than one time series, tends to lend itself to multivariate time series analysis, a field that is still in its infancy within accounting. Early studies dealing with the time series properties of earnings used simple naive and/or index models due to the lack of

tools to identify and estimate more sophisticated models. These include Reilly, et. al. (1972), Little (1962), Little and Rayner (1966), Green (1964), Green and Segal (1967), Copeland and Marioni (1972), Beaver (1970), Craigg and Malkiel (1968), Coates (1972), Ball and Brown (1968) and Brown and Kennelly (1972). These studies used simple 'rule of thumb' models such as average of previous values. Later Dopuch and Watts (1972), Ball and Watts (1972) and others introduced Box-Jenkins (1976) modeling techniques into the accounting literature and focused on the time series behavior of annual earnings. Later, Collins and Hopwood (1980), Brown and Rozeff (1979), Foster (1977), Griffin (1977a), Hopwood and McKeown (1981), Watts (1975) and others, applying the same methods, focused on the stochastic behavior of quarterly earnings. The findings of these studies are discussed below.

The results of the annual earnings studies provide a substantial amount of evidence that annual earnings or earnings per share follow a random walk or a random walk with a drift. Support for this conclusion comes from Ball and Watts (1972), Beaver (1970), Brealy (1969), Little and Rayner (1966), Lookabill (1976) and Salamon and Smith (1977). In addition, Albrecht, et. al. (1977) and Watts and Leftwich (1977) found that full Box-Jenkins analysis of individual series did not provide more accurate forecasts than those of the random walk. Therefore, their results did not provide evidence to reject the hypothesis that the use of a single or 'premier' model is the most appropriate procedure, at least in the cases studied.

Research on quarterly earnings has also involved a consideration of a 'premier' versus individual series model approach. Several univariate

'premier' models have been investigated in the past. These include those of (using the notation of Box and Jenkins (1976)):

(i) Foster (1977), who considered the $(1,0,0) \times (0,1,0)_4$ model

$$(1-\phi B)\ (1-B^4)X_t = a_t + C$$

(ii) Griffin (1977a) and Watts (1975), who considered the $(0,1,1) \times (0,1,1)_4$ model

$$(1-B)(1-B^4)X_t = (1-\Theta B)(1-\Theta B^4)a_t$$

(iii) Brown and Rozeff (1979), who considered the $(1,0,0) \times (0,1,1)_4$ model

$$(1-\phi B)(1-B^4)X_t = (1-\Theta B^4)a_t$$

Note that the Foster model is a special case of the Brown and Rozeff model with $\Theta = 0$. (The Foster model also contains a constant, but Brown and Rozeff (1979) found this parameter to be insignificant.)

Lorek (1979) and Collins and Hopwood (1980) explored the relative predictability of these three premier models and found that there was no advantage to performing individual series indentification, at least for forecasting horizons within one year. Both of these studies focused on the ability of the models to generate annual forecasts from quarterly earnings. The method used involved summing the quarterly forecasts to produce an annual forecast. As the year progressed, realizations were substituted for forecasts in computing the annual sum.

More recently researchers have begun to explore multiple time series models. For example, Hopwood and McKeown (1981) found that the model

$$(y_t - y_{t-4}) = W_0(X_t - X_{t-4}) + \frac{(1-\Theta B^4)}{(1-\phi B)} a_t$$

provided more accurate forecasts than those of the univariate models discussed in the preceding paragraph in predicting annual earnings from quarterly earnings. In this model y_t denotes quarterly earnings per share and X_t a market index of earnings.

Also Beaver, at. al. (1980) developed a time series model that predicted annual earnings more accurately than the random walk model by using security prices as a lead indicator. Similarly, Chant (1980) found forecast improvement by using the money supply as a single leading indicator of earnings. The significance of multiple time series analysis is explored below.

ECONOMIC ISSUES

To our knowledge there has been no clear cut distinction made in previous literature between economic and methodological problems. By economic issues we refer to those issues which primarily relate to utilizing underlying circumstances and economic theories for the purpose of system identification and parameter determination or estimation. On the other hand, we use the term methodological issues to refer to problems which are primarily statistical in nature. There are, of course, issues that are likely to be both statistical and economic in nature.

Modeling From A Systems Viewpoint

Most time series research in accounting has been univariate as opposed to multivariate. By this it is meant that the focus has been on individual time series as opposed to a system of dynamically related

variables. This no doubt at least partially accounts for the poor predictability results of extrapolative statistical models relative to financial analysts (See, for example, Brown and Rozeff (1977), Collins and Hopwood (1980), and Hopwood, et. al. (1981a)) since the analysts use many variables not included in these models (See Barton, et. al., (1981).). The need to develop predictions or expectations from a multivariate system standpoint was recognized two decades ago by Muth (1961) who developed what is now referred to as rational expectations 'theory.' His theory argues that, in an economic environment, individuals cannot be expected to form expectations from only single univariate extrapolation.[1] There is a need to incorporate additional variables according to the relevant economic theory.

A primary reason for the univariate instead of systems approach has been methodological restrictions. The tools for system identification are not well developed. Practically speaking, even simple systems such as those containing several inputs and a single output can be difficult to identify when the inputs are not independent. This is because the specific model form is determined by a set of cross correlation matrices (determined over all lags) between all of the variables.

For example, assume a system of 3 input series $\{x_{1,t}, x_{2,t}, x_{3,t}\}$ and one output series $\{y_t\}$ where no feedback exists between the <u>input</u> series.[2] Next consider the problem of identifying a transfer function of the form

$$y_t = \frac{W_1(B)}{\delta_1(B)} X_{1,t} + \frac{W_2(B)}{\delta_2(B)} X_{2,t} + \frac{W_3(B)}{\delta_3(B)} X_{3,t} + \frac{\theta(B)}{\phi(B)} a_t$$

where the notation of Box and Jenkins (1976) is used to represent the transfer function $W_i(B)/\delta_i(B)$ $(i = 1,3)$ and noise model $\theta(B)/\phi(B)$, with a_t being independent and identically distributed Gaussian white noise. Identification of this system is difficult since the model form in general depends upon all correlations of the form Cor $(V_{i,t}, V_{j,t+k})$ where $\{V_i\}$ represent the 4 model variables $\{y_t, x_{i,t}\}$ which are correlated with each other at lag k $(k = 0, \pm1, \pm2, \ldots)$. The difficulty arises because, to date, there are no well developed general methods for analyzing the patterns of these correlations. (This problem is discussed by Newbold (1981, p. 59).)

One possible way to solve the problem in this case might be through 'successive orthogonalization' which would work as follows:

Since no feedback exists between the $X_{i,t}$ series, we can let

$$X_{1,t} = U_{1,t}$$

$$X_{2,t} = T_{1,2}U_{1,t} + U_{2,t}$$

$$X_{3,t} = T_{1,3}U_{1,t} + T_{2,3}U_{2,t} + U_{3,t}$$

where $\{U_{i,t}\}$ are possibly autocorrelated noise series and $\{T_{i,j}\}$ represent the transfer functions (i.e., a polynomial ratio identified and estimated from the data and theory) between the $\{U_{i,t}\}$ series and input series $\{X_{j,t}\}$. The result is that $U_{1,t}$, $U_{2,t}$ and $U_{3,t}$ are mutually uncorrelated series where the time vectors $\underset{\sim}{X}$ and $\underset{\sim}{U}$ are related by the following transformation

$\underset{\sim}{X} = T \cdot \underset{\sim}{U}$ and T is of the form:

$$\begin{bmatrix} 1 & 0 & 0 \\ T_{1,2} & 1 & 0 \\ T_{1,3} & T_{2,3} & 1 \end{bmatrix}$$

The three $U_{i,t}$ series can then be used to identify three separate single input transfer functions with Y_t being the output variable in each case. Call each of these transfer functions G_1, G_2 and G_3. Then a final model would be of the form $Y_t = G_1U_{1,t} + G_2U_{2,t} + G_3U_{3,t}$. The model could then be reparameterized in terms of the original series (i.e., $U = T^{-1}X$) before forecasting. An alternative approach might be to use T as a simple mathematical transformation that can be found by least squares. For example $T_{1,2}$ can be found by estimating $X_{2,t}$ = $(V_1B - V_2B^2 - ,..., - V_kB^k)U_{1,t}$ where k is chosen to be sufficiently large. This works because in a stable dynamic system a trans-function, $T_{i,j}$, can be approximated by its impulse response weights, the V_i (Box and Jenkins (1976, p. 377-378)). Normally these weights are not used for modeling since their estimation is not efficient. However if one is concerned only with transformation, this does not matter. This approach has the advantage that it can be performed automatically and cheaply on a computer. This approach can easily be extended to a larger number of series.

Note that the successive orthogonalization approach is mathematical/statistical in nature and only facilitates identifying system interrelationships. Whenever possible, economic theory should be given precedence in model identification. However, a difficulty with a pure

economic approach might be that the economic theory might specify only the variables that belong in the system and not the form of the model. In this case successive orthogonalization (SO) or other techniques could be used in conjunction with economic theory. In addition, SO might be used to provide a simplified representation of the system, even when the exact model form is known.

Most of the research in accounting has not utilized economic arguments in the determination of the specific model form, given that the relevant variables in the system have been selected. For example, most researchers have relied on the data to make the choice of an autoregressive versus moving average model. However, Granger and Newbold (1977, p. 23) argue that such a choice is sometimes possible:

> If some economic variable is in equilibrium but is moved from the equilibrium position by a series of buffeting effects from unpredictable events either from or within the economy, such as strikes, or from the outside, and the system is such that the effects are not immediately assimulated, then a moving average model will arise. An example might be a small commodity market that receives a series of news items about the state of crops in producing countries.

Granger and Newbold (1977) base their reasoning on the fact that an infinite order autoregressive model is equivalent to a simple first order moving average model. The same type of reasoning can be applied to transfer function models where an analogous relationship exists between input and output lag models. For example an a MA(1) model $y_t = (1 - \theta B)a_t$ can be written as $(1 - \theta B)^{-1}y_t = a_t$ or $\sum_{i=0}^{\infty} y_t \pi_i B^i = a_t$ (where $\pi_0 \equiv 1$ and $B^0 \equiv 1$), and similarly the transfer function model $y_t = (1 - \omega B)X_t$ can be written as $(1 - \omega_1 B)^{-1}y_t = X_t$ or $\sum_{i=0}^{\infty} y_t \pi_i B^i = X_t$.

Finally, it should be mentioned that the systems approach, while not yet generally applied to accounting time series, is reasonably well developed in science as a whole. In 1954, under the leadership of biologist Ludwig von Bertalanffy, economist Kenneth Boulding, biomathematician Anatol Rapoport, and physiologist Ralph Gerard, the Society for General Systems Theory (now Society for General Systems Research) was formed. Also a general systems theory has evolved which attempts to explain the elements and functions common to all systems. For example, Boulding (1964) has identified five basic principles of systems theory. Also Litterer (1969) identifies some of the characteristics of systems theory. These include interdependancy of objects, holism, entropy, goal seeking, inputs and outputs, transformation, regulation, hierarchy, differentiation and equifinality (For a discussion of these see Schoderbek, et. al. (1980).). Within a time series context several of these characteristics correspond very closely with the discussion in Box and Jenkins (1976) of multiple time series. For example, inputs and outputs correspond to input and output series, transformation to transfer functions, and regulation to feedback and feedforward control. Perhaps general systems theory will be useful in providing a framework for future time series research in accounting, particularly in the area of cybernetics 'closed loop' systems. (An example is given below.) Such systems are very often good representations of economic situations since feedback control (feedback between inputs and outputs) is typically a prerequisite of goal achievement (or goal maintenance). For example, a considerable amount of accounting research has been devoted to the relationship between accounting

information and stock market returns. As discussed above, researchers have hypothesized that the market reacts to new accounting information. In this situation, the market's reaction can be described as movement toward an equilibrium in a feedback system with the goal of supply equalling demand. The new accounting information is an exogeneous input into the system. Consider Figure 1 which contains a supply source

[Insert Figure 1 about here]

(SS), demand source (DS), supply information processor (SIP), demand information processor (DIP), market (M), and disturbance (D). Assume that the system is initially in equilibrium with supply and demand equal. Then allow the introduction of an information disturbance (D). This is transmitted to SIP and DIP which in turn signal SS and DS to adjust the quantities supplied and demanded. The new quantities are passed through the comparer (denoted X) which takes the difference between the two quantities and compares it to the 'ideal' reference input $\ell = 0$. The deviation from the reference input is transmitted to the market which establishes a revised price. The revised price is then transmitted to SS and DS which again adjust the quantities. The process continues until supply and demand are equal. Note that the square boxes represent transfer functions which would be determined from theory and data.

At the heart of the above example is a goal of zero difference between supply and demand. In addition, many examples exist within the accounting environment where other goals exist, such as those deliberately selected by managers, creditors or investors. For example, managers might be interested in zero deviations between budgeted and actual

amounts, creditors might desire to keep bad debits at some fixed percentage of total loans, and investors might desire to maintain some constant level of risk in an investment portfolio. The common characteristic of these situations is that outputs of decisions are used as inputs to future decisions.

To summarize, the systems approach, as applied to accounting, views the time series problem as one of modeling a goal seeking dynamic system where feedback relationships exist between the input and outputs of the system. In perfectly competitive market systems, goal seeking is consistent with establishing market equilibrium, and in other situations it is consistant with the deliberate satisfaction of decision makers' objectives. Feedback between inputs and outputs exists because it is a necessary ingredient in all management control systems (e.g., See Anthony (1978), Buckley and O'Sullivan (1980), and Clowes and Marshall (1975).).

The Systems Approach in Future Research

In this section we deal with several issues relating to application of the systems approach to TSRA in the future. These are: a) what kind of models are appropriate for describing variables in the accounting environment? b) What variables should be included in these models? Each of these issues is discussed individually.

As discussed above, accounting researchers (e.g., Kinney (1978) and Hopwood and McKeown (1981)) have extended univariate extrapolative models to models within the class of multiple input-single output time series models.

These systems, which can be represented by the simple block diagram depicted in Figure 2 and have the advantage that they can incorporate

[Insert Figure 2 about here]

more information than univariate models. Also, in the special case where the output series is white noise, no noise series exists and when only one input series exists, the system in Figure 2 reduces to the case where an ARIMA model is appropriate. However, in spite of its generality, this system has two important limitations which are its inability to incorporate feedback or more than one output series.

A more general approach is depicted in Figure 3 which allows for

[Insert Figure 3 about here]

a feedback loop. Note that this loop includes a reverse direction transfer function (transfer function 2) which can be estimated simultaneously with transfer function 1. In this case, not only does past advertising affect future sales, but past sales affect future advertising. In other words, management might view sales as the output of a system with advertising as a control variable.

Another useful way of depicting the relationship is given in Figure 4. Here the feedback is represented by the simultaneously

[Insert Figure 4 about here]

determined transfer functions, which can be mathematically represented by the vector ARIMA methods discussed by Tiao and Box (1979). These authors represent (in the nonseasonal stationary case) multivariate time series processes by the model

$$\underset{\sim}{\phi}_p(B)\underset{\sim}{Z}_t = \underset{\sim}{\theta}_q(B)\underset{\sim}{a}_t \tag{1}$$

where

$$\underset{\sim}{\Phi}_p(B) = \underset{\sim}{I} - \underset{\sim}{\Phi}_1 B - \ldots - \underset{\sim}{\Phi}_p B^p, \quad \underset{\sim}{\theta}_q(B) = \underset{\sim}{I} - \underset{\sim}{\theta}_1 B - \ldots - \underset{\sim}{\theta}_q B^q$$

are matrix polynomials in the backshift operator B (i.e., $B^k X_t \equiv X_{t-k}$) and:

1) The $\underset{\sim}{\Phi}$'s and $\underset{\sim}{\theta}$'s are K by K matrices where K is the number of series.

2) $\underset{\sim}{Z}_t \equiv \{Z_{i,t}, i=1,K\}$, and $\{Z_{i,t}\}$ is the set of K time series after subtracting off the original series means

3) and $\{\underset{\sim}{a}_t\}$ represents a vector of K identically independent and normally distributed random shocks with mean zero.

Using an example (from Tiao and Box (1979)), assume that (1) takes the special case form of a vector first order moving average process.

$$\begin{bmatrix} Z_{1,t} \\ Z_{2,t} \end{bmatrix} = \begin{bmatrix} 1-\theta_{11}B & 0 \\ -\theta_{21}B, & 1-\theta_{22}B \end{bmatrix} \begin{bmatrix} a_{1,t} \\ a_{2,t} \end{bmatrix} \tag{2}$$

Then letting $a_{2,t} = \beta a_{1,t} + \varepsilon_t$ where ε_t and $a_{1,t}$ are independent, (1) can be expressed in the form

$$Z_{1,t} = (1-\theta_{11}B)a_{1,t}$$

$$Z_{2,t} = \frac{w_0 - w_1 B}{1-\theta_{11}B} Z_{1,t} + (1-\theta_{22}B)\varepsilon_t$$

where $w_0 = \beta$ and $w_1 = \beta\theta_{22} + \theta_{21}$. The resulting set of difference equations yields a transfer function model between $Z_{1,t}$ and $Z_{2,t}$ and a univariate model for $Z_{1,t}$. Note, however, that if the $\underset{\sim}{\theta}(B)$ matrix were not lower diagonal, it would not be possible to describe the final equations in such a simple form. Adding a parameter to the upper right

hand corner of this matrix would introduce feedback, which would be useful in describing systems such as the ones shown in Figures 3 and 4.

While the vector ARIMA provides a large class of models of possible use for future TSRA, it should be emphasized that well developed and tested techniques for determining the orders of p and q in (1) are not presently available for mixed models. Quenouille (1957), Hannon (1969), Morf, Viera and Kailath (1978), Ledalter (1978) and Ansley and Newbold (1979) have used partial correlation matrices to identify models in the pure autoregressive case, but until more general techniques become available, researchers will place a heavy emphasis on diagnostic checking. For example, several simple models might be explored separately and a selection might be made based on diagnostic criteria. Also, the identification can be aided considerably when the researcher can rule out feedback on an a priori basis.

We now address the issue dealing with the choice of variables for model selection. We first acknowledge that such a choice must depend on the individual researcher's objectives. Given this, our opinion is that future research will evolve in the direction of systems that incorporate both components of income and stock price returns. As discussed in an earlier section of this paper, a wide study of accounting research used separate equilibrium models for returns and earnings expectations in research involving information content of earnings. Multivariate time series analysis offers the potential for not only more general models that incorporates both earnings and returns, but also models that describe

the earnings components of a firm as a simultaneous equilibrium. Such a methodology will allow detailed investigation into questions relating to the relative impact of different accounting numbers on stock market returns. Researchers have provided a great deal of evidence that earnings impact on returns, but most of this research has not dealt with relative impact. More general questions might be explored such as the role that a given accounting number plays in the joint determination, with other numbers, of stock market reactions. Since a large amount of financial reporting is mandated, it would be useful, in the face of a proposed (or existing) earnings requirement, to investigate the marginal impact of this disclosure on the market. A disclosure might convey information by itself, but when viewed jointly with other information, it might not. For a further discussion, see Beaver et. al., (1979) and Sunder (1976). The important thing is that findings of research of this type that rely on equilibrium or expectations models are contingent upon the models used. Multivariate time series analysis provides a framework in which very general models can be developed. Finally, the benefits of such models would carry over into many other areas such as internal budgeting and sales forcasting, which often rely on forecasts of components of earnings.

Problems of Aggregation

Accounting and economic variables are very often subjected to either intratemporal (sometimes called component) or intertemporal aggregation. An example of intratemporal aggregation is income, which is an aggregate of various expenses and revenues. Intertemporal aggregation occurs, for example, when quarterly income is aggregated to produce annual income.

Both types of aggregation are particularly important since the results of Brewer (1973) and Rose (1977) show the form of the autoregressive integrated moving model is not invariant under either type of aggregation. Therefore, use of the information in the disaggregate series could be helpful in identifying the correct model form for the aggregated series.

From the standpoint of accounting, aggregation theory has the potential to help in assessing the value of using aggregated versus disaggregated figures. For example, Hopwood, et. al. (1981b), (Also see Cogger (1981) and Hopwood and Newbold (1981).) showed that there is about a 15 to 20 percent information gain in reporting accounting income on a quarterly basis versus an annual basis. They also note that the quarterly earnings models of Brown and Rozeff (1979), Griffin (1977) and Watts (1975), upon aggregation, do not theoretically lead to the random walk model found by most researchers cited above. Specifically they showed that these models aggregate to ARMA (1,1,2) and ARMA (0,2,2) annual models respectively.[3]

As a final point we wish to note that component aggregation theory may have very limited usefulness in deriving aggregate processes on the basis of using economic theory or identification techniques to specify the disaggregated component processes. This can be seen from analyzing the results of Rose (1977) which indicate that even when very simple models exist for the component services, very complicated high-order models will exist for the aggregate process. For example, if m different AR(1) series are aggregated, then the aggregate process in general will be ARMA(m,m-1). Such mixed high order processes are likely to contain

cancelling factors, and therefore highly correlated parameters, thus producing extremely unstable estimation (see Box and Jenkins (1976, p. 248)) and overparameterized models.

Changing Price Levels

The effect of changing price levels (e.g., inflation) on the time series properties of accounting numbers has received little attention. In an attempt to gain some insight into this problem Hopwood (1979) looked at the ratios of variances for the last half to the first half of 50 series. It was found that regardless of the differencing combinations used, the variance was increasing over time for all of the sample firms. Furthermore, it was found that this problem was mitigated by dividing the series numbers by a price index. This procedure also resulted in improved forecasts.

Another way of dealing with this problem might be the use of the Box and Cox (1964) transformation, which is of the class

$$Y_t = (X_t^{\lambda}-1)/\lambda \qquad (\lambda \neq 0)$$

$$= \log X_t \qquad (\lambda = 0)$$

where X_t is the series to be transformed, Y_t is the transformed series and λ is the transformation parameter.

Hopwood, et. al. (1981a) found $\hat{\lambda}$ to be significantly different from 1 for about one-half of their sample. For these series there was a marked improvement in forecast accuracy after applying the transformation.

Intervention Analysis and Outlier Problems

Box and Tiao (1975) introduced intervention analysis to allow for the impact of a single event such as a strike on the time series. This procedure involves adding to the model a dummy parameter which is greater than zero when the event occurs and zero for all other times. (In some cases more than one intervention parameter might be desirable.)

As a simple example, consider a series, x_t, that follows an AR(1) process. In addition assume that a strike severely impacts this series at time t=20. In this case a standard ARIMA model is inappropriate, but an alternative model that might be useful is $(1 - \phi B)(X_t + \delta_t \varepsilon) = a_t$, where $\delta_t = 1$ for $t = 20$ and $\delta_t = 0$ otherwise, and $\{\phi, \varepsilon\}$ are simultaneously estimated model parameters. These kinds of events are very common in the accounting environment. This is evidenced by the results of Collins and Hopwood (1980) who found a number of cases (strikes, etc.) where an intervention term could have been used when modeling quarterly earnings per share.

To gain an idea of the magnitude of the problem, we made a cursory examination of about 250 COMPUSTAT tape companies. We noted that occasionally the earnings of a firm would take a violent swing. (For example, during the third quarter of 1974, the earnings of AMF incorporated made a ten-fold drop from the same quarter in the previous year and a five-fold drop from the previous quarter.) These data indicated that studies should explicitly consider the effects of interventions on the earnings process when time series models are used. Otherwise the intervening events might have a serious impact on the parameter estimates and resulting forecasts. In addition the intervening event has the potential for having very unpredictable effects on identification via

the correlation functions. Therefore in serious cases one might consider replacing very extreme observations, caused by intervening events, by rough estimates before identification. Once a correct model is identified, the extreme observations can be reincorporated in the data set for estimation as the ARIMA-intervention model.

A second potential use of intervention analysis is the inclusion of the intervention variable for purposes of assessing the impact of a particular action on some time series of interest. For example, Griffin (1977) used this approach to examine the effect of bond reclassification on conditional security returns. His models included a single input transfer function with an intervention variable. The intervention parameter therefore provided a test for the information content of the reclassification. His results indicated that this parameter was significant and that bond reclassification conveyed information to the market. (For a similar study see Deakin (1976).). In a similar vein, Larcker, at. al. (1980) provide convincing arguments for the use of Griffin's methodology as a general methodology for this type of research.

A problem somewhat related to intervening events is outliers. We refer to outliers as extreme observations that cannot be accounted for by specific events. This problem is much more difficult, because, unlike intervening events, detection of outliers must be based on distribution theory (Barnett and Lewis (1978, p. 23)). Unfortunately theoretical results (given by Abraham and Box (1979) and Fox (1972)) presently exist only for the autoregressive case. However, since moving average models can be approximated by high order autoregressive models, these results might prove to be of general use, at least in the detection of severe outliers.

It is difficult to assess the degree to which the outlier problem exists relating to earnings series. As discussed above, analysis of a large number of COMPUSTAT firms' earnings indicated that unusual observations exist, but without conducting an exhaustive study we cannot say how many can be attributed to identifiable events. It should be pointed out, however, that outliers may not be readily apparent when detected by visual techniques such as plotting, etc.

METHODOLOGICAL ISSUES

Exact Likelihood Estimation

Our analysis of the literature revealed that virtually all research studies have used least squares estimation. It should be noted that this approach is only an approximation of maximum likelihood estimation, and Ansley and Newbold (1980) have shown that it produces inferior parameter estimates (i.e., those leading to larger forecast errors). The loss in parameter estimation precision is greater for shorter series since the exact likelihood approach provides better estimates of the initial conditions (or 'start up values') than the techniques of Box and Jenkins (1976). The shorter the series, the more the parameter estimates depend on these conditions.

Stationarity-invertability Conditions

As discussed by Box and Jenkins (1976) theory requires that the model parameters satisfy certain stationarity-invertability conditions. Our examination of tabled models in the accounting literature revealed a large number of models with parameters violating these conditions. As is well known, these models can lead to extremely large forecast errors.

Ansley and Newbold (1980) show that this problem is aggravated by the use of least squares, as opposed to exact likelihood estimation. If least squares is to be used, the nonlinear regression can easily be constrained to keep the parameters within bounds. We have developed a program which prevents parameters from going out of bounds by adding the following term to the sum of the squares during estimation:

$$|B+\delta-MR|*10^{20}$$

where B is the poloynomial root boundary described by Box and Jenkins (1970), MR is the minimum polynomial root, and δ is a small constant which is arbitrarily close to zero. This term is only added when the estimation routine tries a parameter value out of bounds. This simple program modification can typically be made with only a small number of statements when the roots are available. Further details relating to modifying specific programs will be provided upon written request to the authors.

Correlated Error Structure

A large portion of accounting time series studies involve model estimation for a sample of firms within a common time interval. Since all firms are subject to common economic influences, these circumstances will lead to contemporaneously correlated errors. In the linear regression case, Zellner (1962, 1963) has referred to this as the problem of 'seemingly unrelated regression equations (SUR).' It is well known (See for example, Judge et al. (1980).) that simultaneous modeling of different firms' data can lead to more efficient estimation when this problem occurs (For a SUR literature review see Srivastava and Dwivedi (1979).). Along these lines and those of Nelson (1976), Palm (1977) and

Reinsel (1979), Salamon and Moriarty (1980) presented an application of the SUR concept to univariate time series models (henceforth SURARMA). The results of Salamon and Moriarty, while for a small number of firms, indicated that SURARMA procedures improved forecasts for monthly unit sales and quarterly earnings per share.

It is interesting to note that for some firms there might exist non-contemporaneously correlated error disturbances. This is because the effects of some general economic shocks are likely to occur at different times for different firms. For example, it is widely known that increases in mortgage interest rates will precede a decline in the earnings of the construction industry. In such a situation the multivariate ARIMA methods (discussed above) of Tiao and Box (1979) might prove useful.[4]

One drawback of the SURARMA approach is that it requires estimation (or knowledge) of the $(N^2-N)/2$ covariances between the errors of the N series being modeled. For 50 firms this would require the estimation of 1,225 numbers. For series of lengths typically found in accounting studies (i.e., 50-75 observations), this would involve considerable estimation risk. That is, the gains from simultaneous estimation might be more than eliminated by the error associated with the estimation of the variance-covariance matrix of disturbance errors.

It should be noted that an alternative approach to SURARMA might be the elimination of common disturbances via industry, market or other indices. This could be accomplished by use of single or multiple input transfer function-noise model. It would be interesting to compare the market index transfer function approach of Hopwood and McKeown (1981) with the SURARMA approach of Salamon and Moriarty

(1980). The important thing is that both of these studies take a 'systems approach.' It is of our opinion that this approach will lead not only to better forecasting but to a better understanding of the interrelationships of variables within the accounting environment.

System Stationarity

The stationarity of a Gaussian time series (as defined by Box and Jenkins (1970, p. 26) and Nelson (1973, p. 20)) requires that the mean, variance and autocovariances be constant over time. A constant mean typically can be achieved by differencing. However, as stated above, Hopwood et al. (1981) found that quarterly earnings do not exhibit constant variances over time.

The requirement of constant autocovariances, to our knowledge, has not been investigated to any considerable degree in accounting. Also existence of this problem is very plausible since most firms undergo structural and environmental changes over time. Examples of these changes are changing product mixes, industry trends, etc. Some of these changes might be dealt with through simple intervention analysis, but others might require more elaborate measures. Finally note that the same problem can occur with multiple time series if the cross-covariance functions change over time.

The problem of changing autocovariances can be dealt with by use of the general dynamic linear model (DLM) discussed by Harrison and Stevens (1976).[5] While space considerations do not permit an expanded discussion here, we note that the DLM incorporates a class of models based on the Kalman (1960) filter which contains the ARIMA class as a proper subset (see Harvey and Phillips (1979)).[6] More important here

is that it allows for models where the underlying process changes over time. A simple example of this might be the model $(1-\phi_t B)y_t = a_t$, where ϕ_t is time dependent and follows a first order autoregressive process.

One possible line of future research might be to investigate the annual earnings in the context of the DLM. It is possible that the success of the random walk model relative to more specific models for this variable can be attributed to an earnings process that changed over time. This random walk model does not rely on sample data from the distant past, but identification and estimation of other models may be severely impacted by the changing process.

FUTURE RESEARCH

The basic thrust of this paper has been to depict time series research in accounting as moving from simple univariate analysis to a more general dynamic systems approach. In our opinion this will lead to future research which combines econometrics, economic theory and time series model building. As discussed above, we feel that, whenever possible, economic theory should be brought to bear on system modeling, but such an approach can be supplemented by identification based on available data. This view is summarized by Jenkins (1979, pp. 90-91):

> The most serious weakness in econometric model building seems to be the absence of a model building methodology. It is argued by many that 'economic theory' should be the sole arbiter as to what structures should be built into a model. ... However, no 'theory' in any subject is sacrosant. ...a more sensible approach would seem to be to use theory and

> prior knowledge to influence the choice of variables for a particular situation and then to combine this knowledge with empirical investigation in order to arrive at models which are representationally adequate.

Finally, a general dynamic systems approach will require research on interrelationships between variables in the accounting environment. Such interrelationships might be characterized by mutual crosscorrelation, aggregation and feedback. In addition, it will be necessary to deal with problems such as changing variances (and possibly covariances) within the context of the general dynamic linear model discussed above. These problems will be subject to the additional problem of large outliers.

FOOTNOTES

[1]Muth's theory has various interpretations. Ours is consistant with Judge et. al. (1980) who, in explaining the theory, say: "Rational expectations are simply conditional expectations of the variable being forecast using all observations of it and related variables up to the time of forecast" [emphasis added].

[2]We do not view the absence of feedback between the input series as overly restrictive. Since feedback typically exists for purposes of control over the output series, it is usually defined as a coupling relationship between the input and output series rather than between the input series themselves.

[3]Our analysis of the Hopwood, et. al., data indicated that these derived models did not provide forecasts more accurate than those of the random walk. Using their data and error computation method, we measured the ratio of mean squared forecast errors for the random walk to the derived model to be almost exactly 1.

[4]Also see Jenkins and Alavi (1981).

[5]We don't wish to preclude other techniques for dealing with the problem such as non-linear time series analysis as discussed by Priestley (1981).

[6]See also Kalman and Bucy (1961).

REFERENCES

Abdel-khalik, A. R. and R. B. Thompson (1977-78), Research on earnings forecasts: the state of the art, The Accounting Journal, 1, 180-209.

Abraham, B. and G. E. Box (1979), Bayesian analysis for some outlier problems in time series, Biometrika, 66, 229-36.

Albrecht, W. S., L. L. Lookabill and J. C. McKeown (1977), The time series properties of annual earnings, Journal of Accounting Research 15, 226-44.

Albrecht, W. S. and J. C. McKeown (1977), Toward an extended use of statistical analytical reviews in the audit, Proceedings of Auditing Research Symposium, Center for International Education and Research in Accounting, University of Illinois, 53-69.

Ansley, C. F. and P. Newbold (1979), Multivariate partial correlations, Proc. Bus. Econ. Stat., Am. Statist. Assoc., 349-353.

Ansley, C. F. and P. Newbold (1980), Finite sample properties of estimates for autoregressive moving average models, J. Econometrics 13, 159-183.

Anthony, R. A. (1978), Characteristics of management control systems, in Readings in Cost Accounting Budgeting and Control, William E. Thomas ed., Southwestern Publishing Co., 53-68.

Ball, R. and P. Brown (1968), An empirical evaluation of accounting income numbers, Journal of Accounting Research 6, 159-78.

Ball, R. and R. L. Watts (1972), Some time series properties of accounting income numbers, Journal of Finance 27, 663-81.

Barnea, A., J. Ronen and S. Sadan (1976), Classificatory smoothing of income with extraordinary items, Accounting Review 51, 110-22.

Barnett, V. and T. Lewis (1978), Outliers in Statistical Data, New York: John Wiley and Sons.

Barton, E., W. B. Carper and T. S. O'Connor (1981), Views of Chartered Financial Analysts on earnings forecasts: a behavioral study, Journal of Business Forecasting Methods & Systems, 1, 10-14.

Beaver, W. H. (1970), The time series properties of earnings, Empirical Research in Accounting: Selected Studies (Supplement to Journal of Accounting Research 8), 62-99.

Beaver, W. H., R. G. Clarke and W. F. Wright (1979), The association between unsystematic security returns and magnitude of earnings forecast errors, Journal of Accounting Research 17, 316-340.

Beaver, W. H., J. W. Kennelly and W. M. Voss (1968), Predictive ability as a criterion for the evaluation of accounting data, Accounting Review 43, 678-83.

Beaver, W. H., R. Lambert and D. Morse (1980), The information content of security prices, Journal of Accounting and Economics 2, 3-28.

Box, G. E. P. and D. R. Cox (1964), An analysis of transformations, Journal of Royal Statistical Society B 26, 211-43.

Box, G. E. P. and G. M. Jenkins (1976), Time Series Analysis, Forecasting and Control, San Francisco: Holden Day.

Box, G. E. P. and G. C. Tiao (1975), Intervention analysis with applications to economic and environmental problems, Journal of American Statistical Association 70, 70-9.

Boulding, K. (1964), General systems as a point of view, in M.D. Mesarovic, ed. Views on General Systems Theory, New York: John Wiley and Sons.

Brealey, R. A. (1969) Introduction to Risk and Return from Common Stocks, Boston: M.I.T. Press.

Brewer, K. R. W. (1973) Some consequences of temporal aggregation and systematic sampling for ARMA and ARMAX models, Journal of Econometrics 1, 133-54.

Brown, P. and J. W. Kennelly (1972), The informational content of quarterly earnings: an extension and some further evidence, Journal of Business 45, 403-15.

Brown, L. D. and M. S. Rozeff (1978), The superiority of analyst forecasts as measures of expectations: evidence from earnings, Journal of Finance 33, 1-16.

Brown, L. D. and M. S. Rozeff (1979), Univariate time series models of quarterly earnings per share: a proposed premier model, Journal of Accounting Research 17, 179-89.

Buckley, J. W. and P. O'Sullivan (1980), Control theory and management accounting, in Management Accounting 1980, H. P. Holzer ed., University of Illinois, Department of Accounting, 55-78.

Chant, P. D. (1980), On the predictability of corporate earnings per share behavior, Journal of Finance 35, 13-21.

Clowes, G. A. and S. A. Marshall (1975), A control engineering framework for planning, in Long Range Planning, Perammon Press.

Coates, R. (1972), The predictive content of interim reports--a time series analysis, Journal of Accounting Research (Supplement) 10, 132-44.

Cogger, K. O. (1981), A time series analytic approach to aggregation issues in accounting data, Journal of Accounting Research 19, forthcoming.

Collins, W. A. and W. S. Hopwood (1980), A multivariate analysis of annual earnings forecasts generated from quarterly forecasts of financial analysts and univariate time series models, Journal of Accounting Research 18.

Copeland, R. M. and R. J. Marioni (1972), Executives forecasts of earnings per share versus forecasts of naive models, Journal of Business 45, 497-512.

Cragg, J. G. and B. G. Malkiel (1968), The consensus and accuracy of some predictions of the growth of corporate earnings, Journal of Finance 23, 67-84.

Deakin, E. B. (1976), Accounting reports, policy interventions, and the behavior of securities returns, Accounting Review 51, 590-603.

Dopuch, N. and R. L. Watts (1972) Using time series models to assess the significance of accounting changes, Journal of Accounting Research 10, 180-94.

Fama, E. F. (1965), The behavior of stock market prices, Journal of Business 38, 34-105.

Fama, E. F. (1970), Efficient capital markets: a review of theory and empirical work, Journal of Finance 25, 383-417.

Financial Accounting Standards Board (1976), Tentative Conclusions on Objectives of Financial Statements of Business Enterprises.

Financial Accounting Standards Board (1978), Statement of Financial Accounting Standards No. 1: Objectives of Financial Reporting and Elements of Financial Statements of Business Enterprises.

Foster, G. (1977), Quarterly accounting data: Time series properties and predictive ability results, Accounting Review 52, 1-21.

Fox, A. J. (1972), Outliers in time series, Journal of the Royal Statistical Society B 43, 350-363.

Frank, W. (1969), A study of the predictive significance of two income measures, Journal of Accounting Research 7, 123-136.

Gonedes, N. J., N. Dopuch and S. H. Penman (1976), Disclosure rules, information-production, and capital market equilibrium: the case for forecast disclosure rules, Journal of Accounting Research 16, 89-137.

Granger, C. W. J. and P. Newbold (1977), Forecasting Economic Time Series, New York: Academic Press.

Green, D. (1964), Towards a theory of interim reports, Journal of Accounting Research 2, 35-49.

Green, D. and J. Segall (1967), The predictive power of first quarter earnings reports, Journal of Business 40, 44-55.

Griffin, P. A. (1977a), The time series behavior of quarterly earnings: preliminary evidence, Journal of Accounting Research 15, 71-83.

Griffin, P. A. (1977b), Common stock price adjustments to rating changes: a methodological emphasis, Research paper No. 439, Stanford University.

Hannan, E. J. (1969), The identification of vector mixed autoregressive-moving average systems, Biometrika 56, 223-225.

Harrison, P. J. and C. F. Stevens (1976), Bayesian forecasting, J. R. Statist. Soc. B 38, 205-247.

Harvey, A. C. and G. P. A. Phillips (1979), Maximum likelihood estimation of regression models with autoregressive moving average disturbances, Biometrika 66, 49-58.

Hopwood, W. (1979), An empirical investigation into the effect of changes in the general price level on the time series properties of quarterly earnings per share, University of Illinois College of Commerce Working Paper #581, Urbana, Illinois.

Hopwood, W. S. and J. C. McKeown (1981), An evaluation of univariate time series earnings models and their generalization to a single input transfer function, Journal of Accounting Research 19, forthcoming.

Hopwood, W. S., J. C. McKeown and P. Newbold (1981a), Power transformations in time series models of quarterly earnings per share, Accounting Review 56, 927-933.

Hopwood, W. S., J. C. McKeown and P. Newbold (1981b), The additional information content of quarterly earnings reports: intertemporal disaggregation, Journal of Accounting Research 20, forthcoming.

Hopwood, W. S. and P. Newbold (1981), Time series analysis in accounting: A survey and analysis of recent issues, Journal of Time Series Analysis 1, 135-144.

Jenkins, G. M. (1979), Practical Experiences with Modelling and Forecasting Time Series, Lancaster: G. J. P.

Jenkins, G. M. and A. S. Alavi (1981), Some aspects of modelling and forecasting multivariate time series, Journal of Time Series Analysis 2, 1-48.

Joy, O. M., R. H. Litzenberger and R. W. McEnally (1977), The adjustment of stock prices to announcements of unanticipated changes in quarterly earnings, Journal of Accounting Research 15, 207-25.

Judge, G. G., W. E. Griffiths, R. C. Hill and T. Lee (1980), The Theory and Practice of Econometrics, New York: John Wiley and Sons.

Kalman, R. E. (1960), A new approach to linear filtering and prediction problems, Journal of Basic Engineering D82, 35-44.

Kalman, R. E. and R. S. Bucy (1961), New results in linear filtering and prediction problems, Journal of Basic Engineering D83, 95-107.

Kinney, W. R. (1978), ARIMA and regression in analytical review: an empirical test, Accounting Review 53, 48-60.

Larcker, D. F., L. A. Gordon and G. E. Pinches (1980), Testing for market efficiency: a comparison of cumulative residual methodology and intervention analysis, Journal of Financial and Quantitative Analysis 15, 253-266.

Ledolter, J. (1978), The analysis of multivariate time series applied to problems in hydrology, J. Hydrol. 36, 327-352.

Lintner, J. (1965), The valuation of risk assets and selection of risky investments in stock portfolios and capital budgets, Review of Economics and Statistics 47, 13-37.

Litterer, J. A. (1969), Organizations: Systems Control and Adaptation, Vol. 2, New York: John Wiley and Sons.

Little, I. M. D. (1962), Higgledy piggledy growth, Oxford University Institute of Statistics.

Little, I. M. D. and A. C. Rayner (1965), Higgledy Piggledy Growth Again, Oxford: Blackwell.

Lookabill, L. L. (1976), Some additional evidence on the time series properties of accounting earnings, Accounting Review 51, 724-38.

Lookabill, L. L. and J. C. McKeown (1976), Time series properties of stock market returns, AIDS National Convention Proceedings.

Lorek, K. S. (1979), Predicting annual net earnings with quarterly earnings time-series models, Journal of Accounting Research 17 190-204.

Lorek, K. S. and J. C. McKeown (1978), Effects of reduction in number of observations on time series analysis of quarterly earnings data, Journal of Accounting Research 18, 204-14.

McKeown, J. C. and K. S. Lorek (1978), A comparative analysis of predictive ability of adaptive forecasting, reestimation and reidentification using Box-Jenkins time series analysis, Decision Sciences 9, 658-72.

Morf, M., A. Viera and T. Kailath (1978), Covariances characterization by partial correlation matrices, Ann. Statist. 6, 643-648.

Mossin, J. (1966), Equilibrium in a capital market, Econometrica 34, 768-83.

Muth, J. F. (1961), Rational expectations and the theory of price movements, Econometrica 29, 315-335.

Nelson, C. R. (1976), Gains in efficiency from joint estimation of systems of autoregressive-moving average processes, Journal of Econometrics 4, 341-348.

Nelson, C. R. (1973), Applied time series analysis for managerial forecasting, San Francisco: Holden Day.

Newbold, P. (1981), Some recent developments in time series analysis, International Statistical Review 49, 53-66.

Norby, W. C. (1973), Disclosure of Corporate Forecasts to the Investors, The Financial Analysts Federation.

Palm, F. (1977), On univariate time series methods and simultaneous equation econometric methods, Journal of Econometrics 5, 379-388.

Penman, S. H. (1980), An empirical investigation of the voluntary disclosure of corporate earnings forecasts, Journal of Accounting Research 18, 132-160.

Praetz, P. D. (1979), Testing for a flat spectrum on efficient market price data, Journal of Finance 34, 645-58.

Prakash, P. and A. Rappaport, eds. (1974), Public Reporting of Corporate Financial Forecasts, New York: Commerce Clearing House.

Priestley, M. B. (1981), State-dependent models: a general approach to non-linear tim series analysis, Journal of Time Series Analysis 1, 47-72.

Quenouville, M. H. (1957), The Analysis of Multiple Time Series, London: Griffin.

Revsine, L. (1971), Predictive ability, market prices and operating flows, Accounting Review 46, 480-89.

Reilly, R. K., E. L. Morgensen and M. West (1972), The predictive ability of alternative parts of interim financial statements, Empirical Research in Accounting: Selected Studies (Supplement to Journal of Accounting Research 10), 105-24.

Reinsel, G. (1979), FIML estimation of the dynamic simultaneous equations model with ARIMA disturbances, Journal of Econometrics 9, 263-281.

Rose, D. E. (1977), Forecasting aggregates of independent ARIMA processes, Journal of Econometrics 5, 323-345.

Salamon, G. L. and E. D. Smith (1977), Additional evidence on the time series properties of reported earnings per share: comment, Journal of Finance 32, 1795-1801.

Samuelson, R. A. (1980), Should replacement cost earnings be included in income? Accounting Review 55, 254-68.

Schoderbek, C. G., P. P. Schoderbek and A. G. Kefalas (1980), Management Systems, Dallas: Busines Publications, Inc.

Sharpe, W. F. (1964), Capital asset prices: a theory of market equilibrium under condition of risk, Journal of Finance 19, 425-42.

Simmons, J. and J. Gray (1969), An investigation of the effect of differing accounting frameworks on the prediction of income, Accounting Review 44, 757-76.

Smith, E. D. (1976), Effect of separation of ownership from control on accounting policy decisions, Accounting Review 51, 707-23.

Srivastava, V. K. and T. D. Dwivedi (1979), Estimation of seemingly unrelated regression equations, Journal of Econometrics 10, 14-32.

Stringer, K. W. (1975), A statistical technique for analytical review, Studies on Statistical Methodology in Auditing (Supplement to Journal of Accounting Research 13), 1-9.

Sunder, S. (1976), Comment on competitive information in the stock market: an empirical study of earnings, dividends and analysts' forecasts, Journal of Finance 31.

Tiao, G. C. and G. E. P. Box (1979), An introduction to applied multiple time series analysis, unpublished technical report no. 582, University of Wisconsin, Department of Statistics.

Wall Street Journal (1978), SEC again to urge profit projections, other operating forecasts by companies, February 16, p. 6.

Watts, R. L. (1975), The time series behavior of quarterly earnings, Department of Commerce, University of Newcastle.

Watts, R. L. and R. W. Leftwich (1977), The time series of annual accounting earnings, Journal of Accounting Research 15, 253-271.

Zellner, A. (1962), An efficient mehtod of estimating seemingly unrelated regressions and tests of aggregation bias, Journal of the American Statistical Association 57, 348-368.

Zellner, A. (1963), Estimates for seemingly unrelated regression equations: some exact finite sample results, Journal of the American Statistical Association 58, 972-992.

M/B/206

Figure 1

A Block Diagram for Market Price Equilibrium

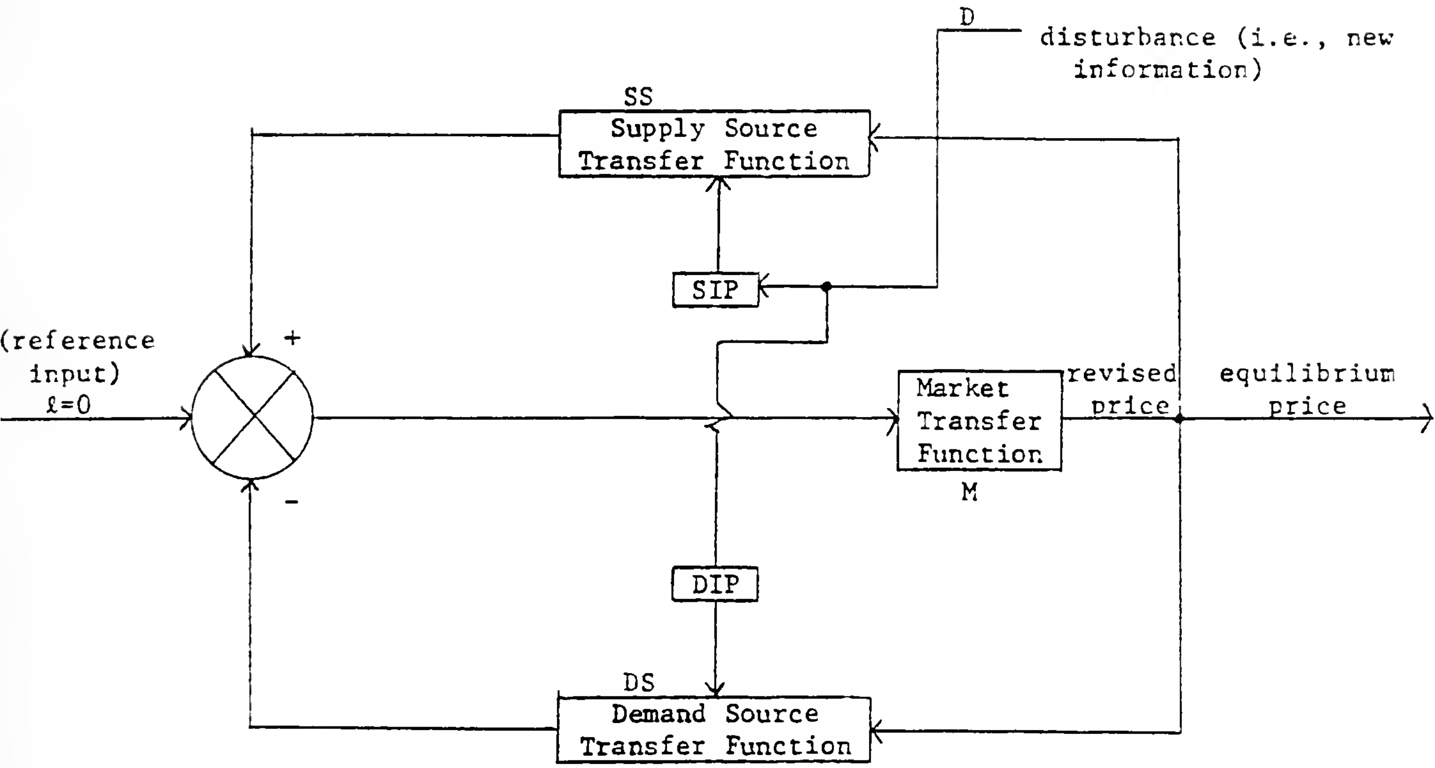


Figure 2

Case A - Block Diagram for the Single Input, Single Output Case

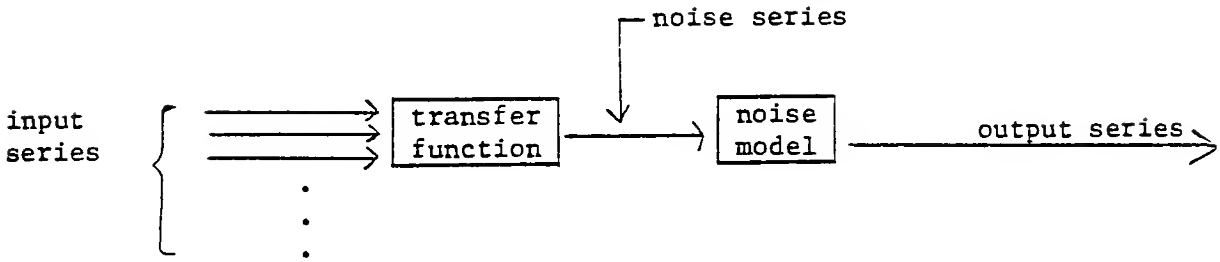


Figure 3

Case B - Block Diagram with Feedback Loop

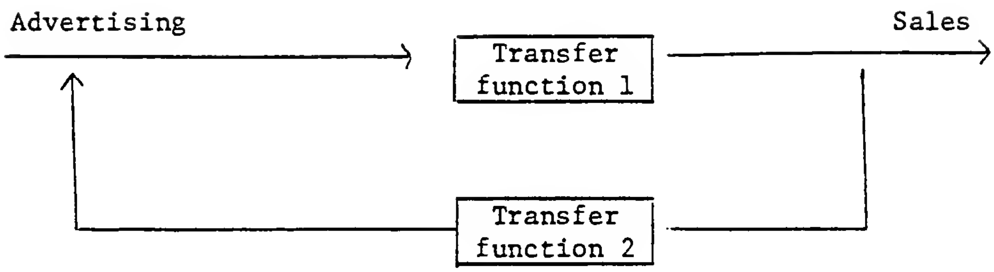
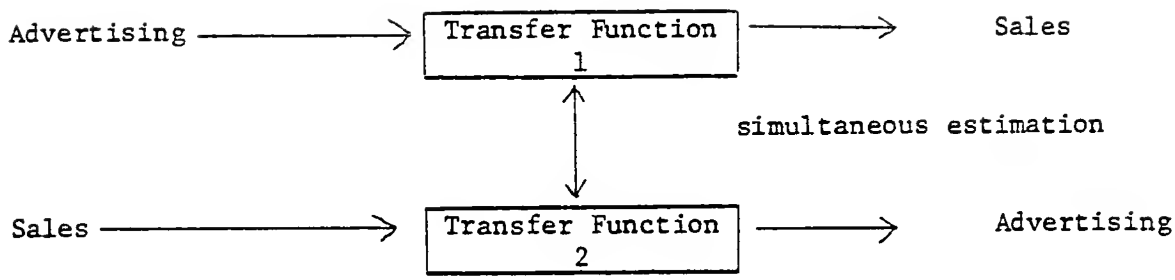


Figure 4


Advertising
Transfer Function 1
Sales
simultaneous estimation
Sales
Transfer Function 2
Advertising